Using Scientific Visualization to Represent Soil Hydrology Dynamics

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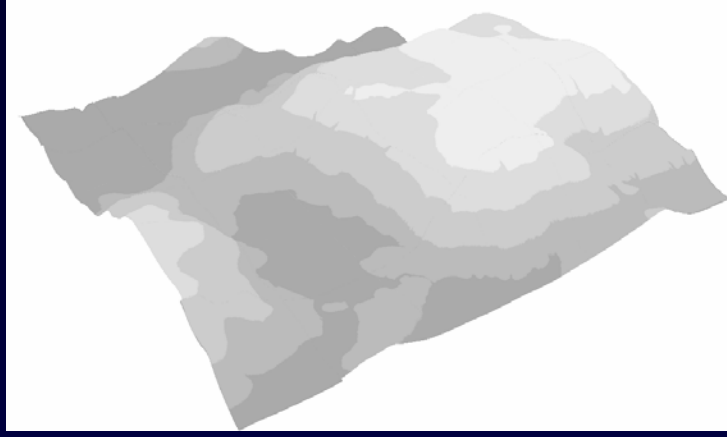
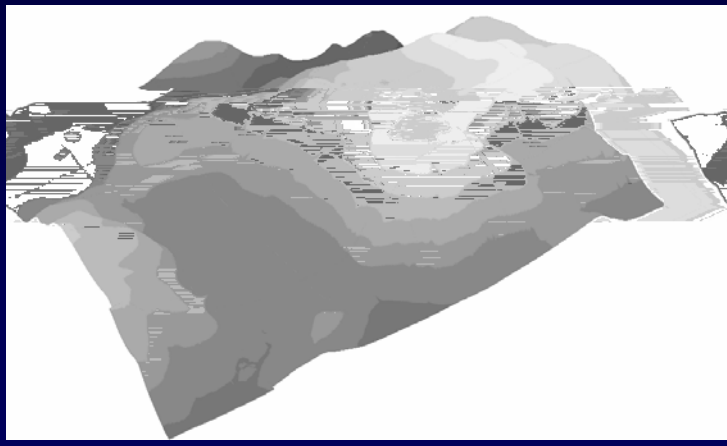
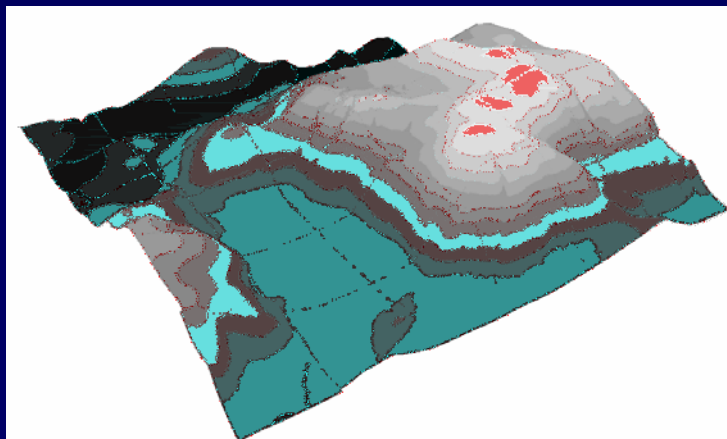


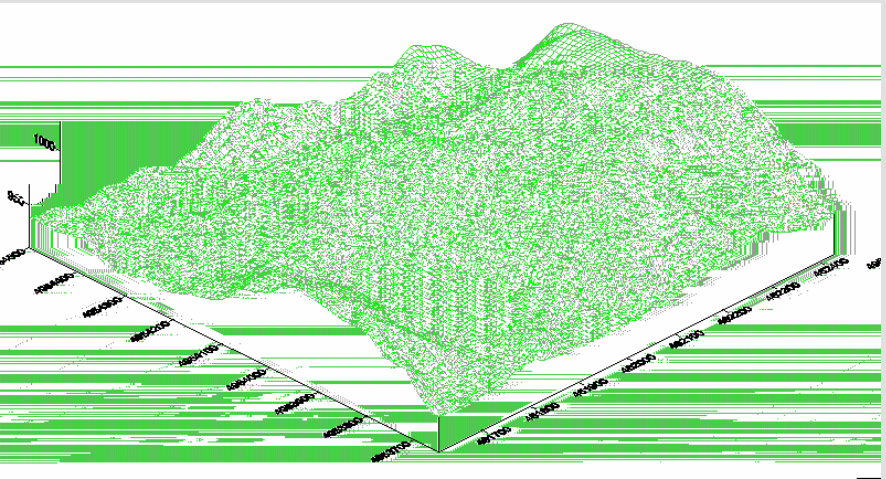


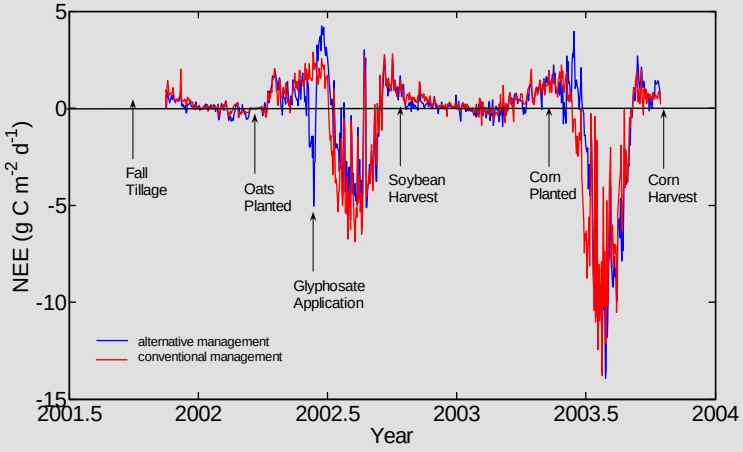


Mapping Soil Space-Time Continuum

Space

Time





Space

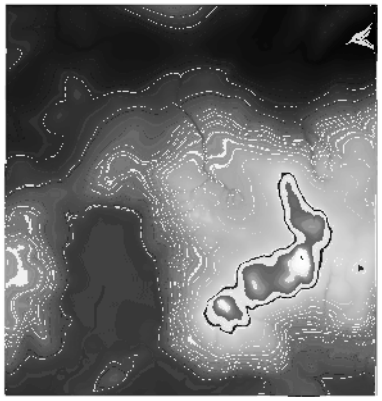
Environmental Correlation

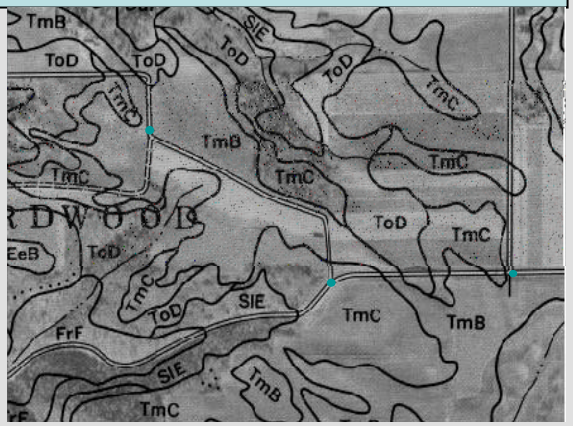
Geostatistical Approaches

Expert Systems

Isarithmic Map
Smoothed Surface

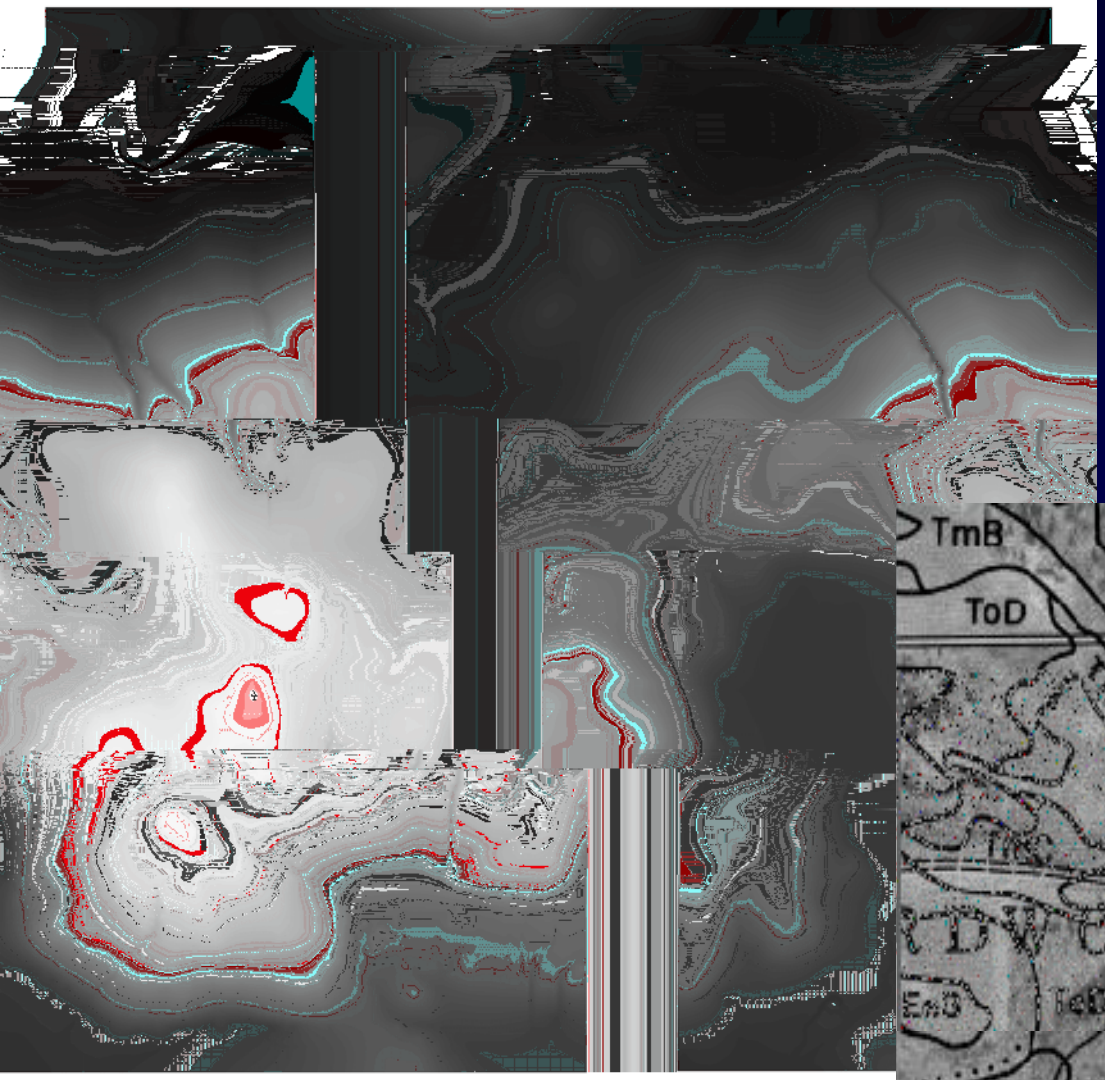
Choropleth Map
Discrete Areas

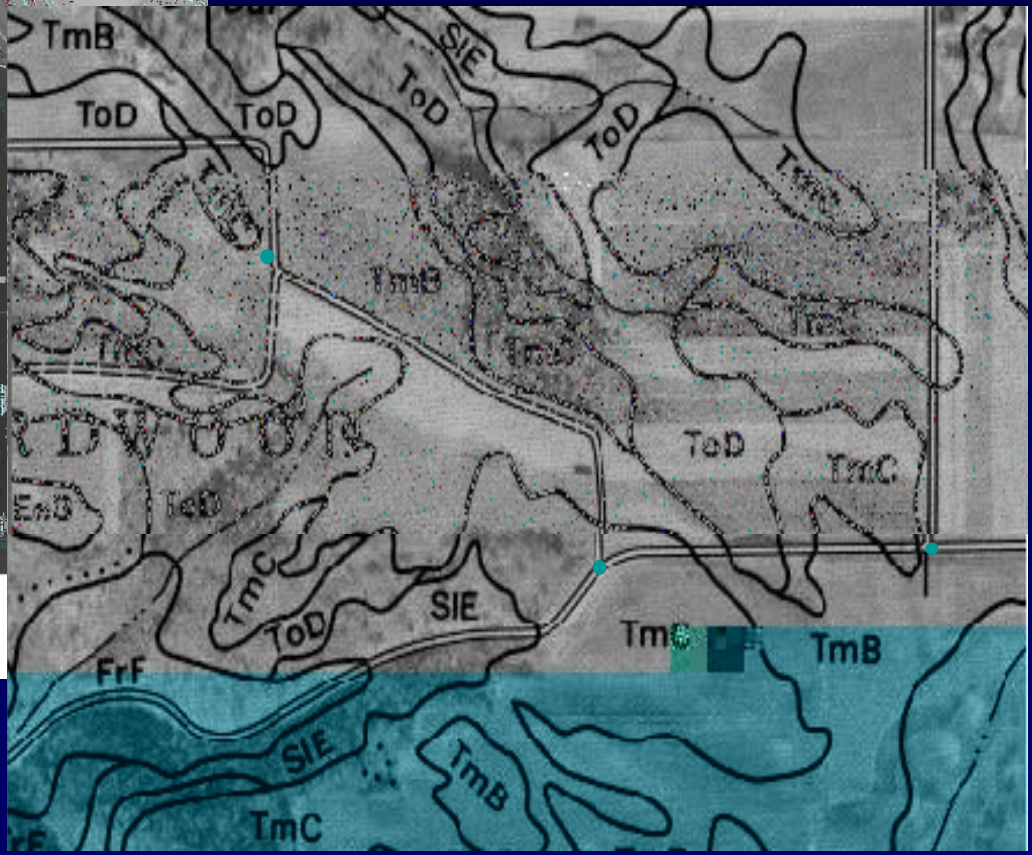




Spatially Explicit

Temporally Static





Time

Models

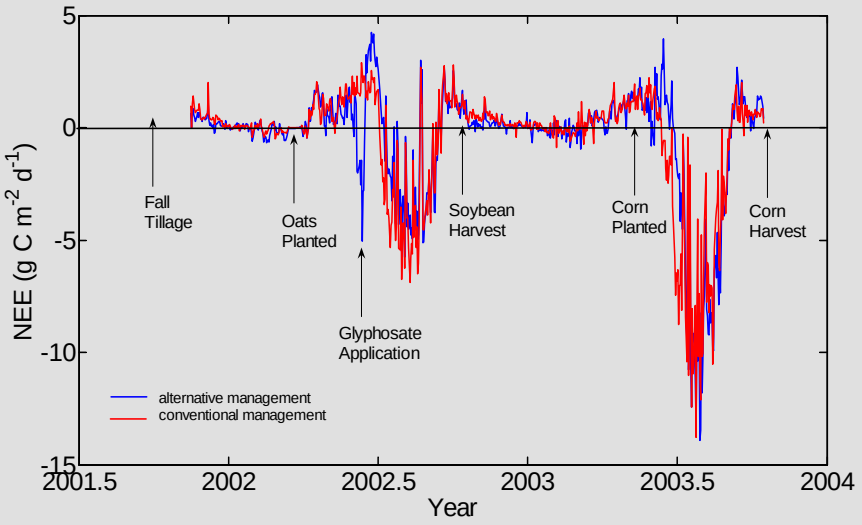
Data

Deterministic

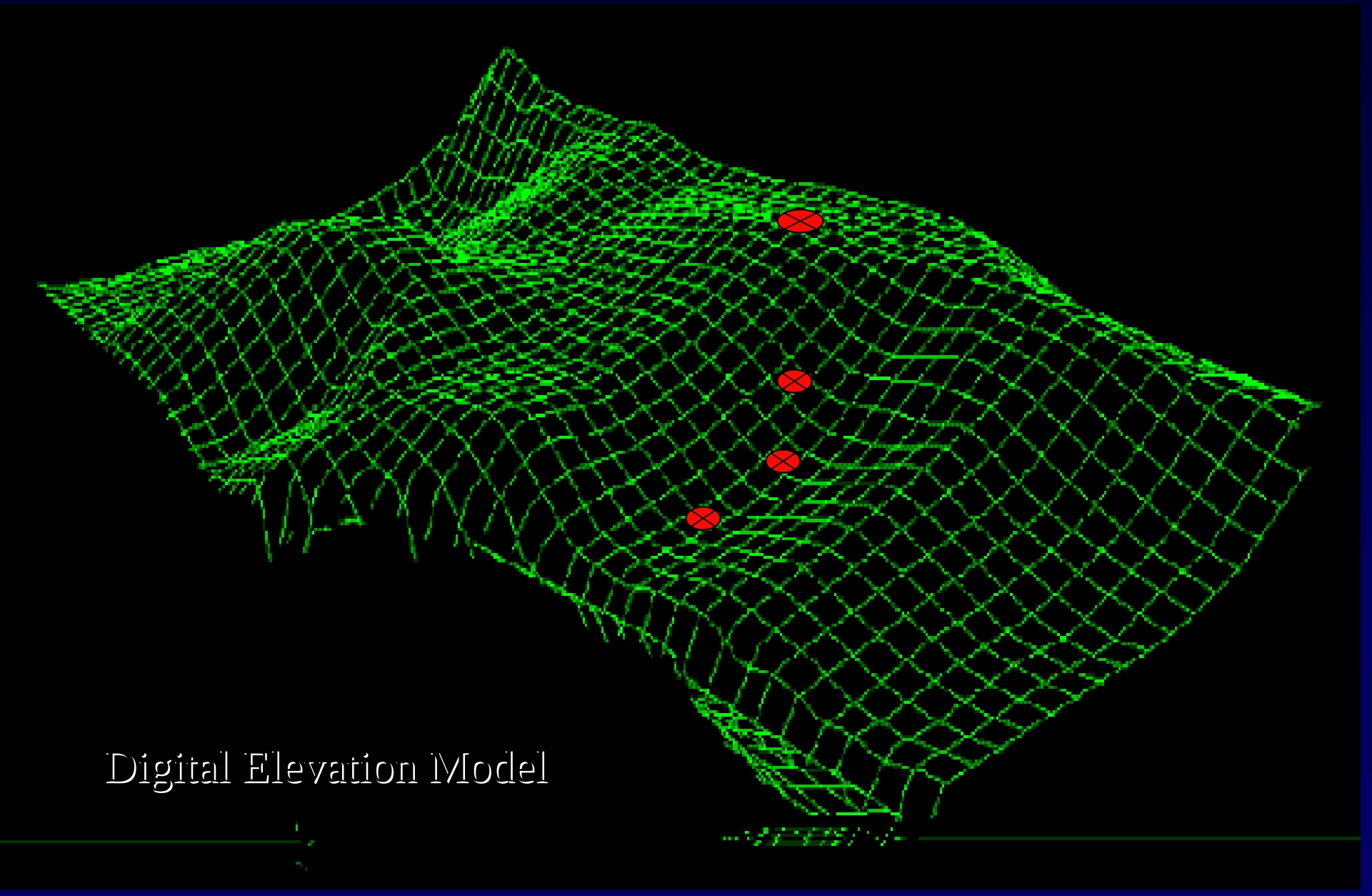
Stochastic

Empirical

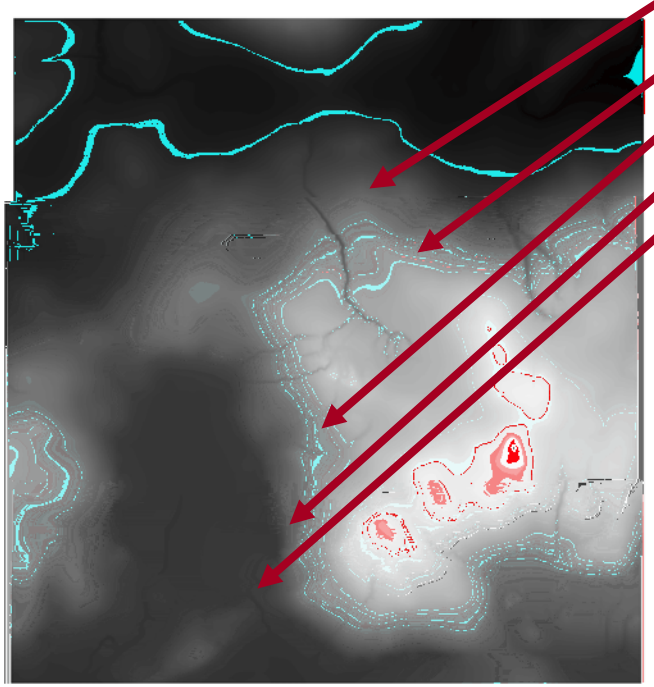
Conceptual

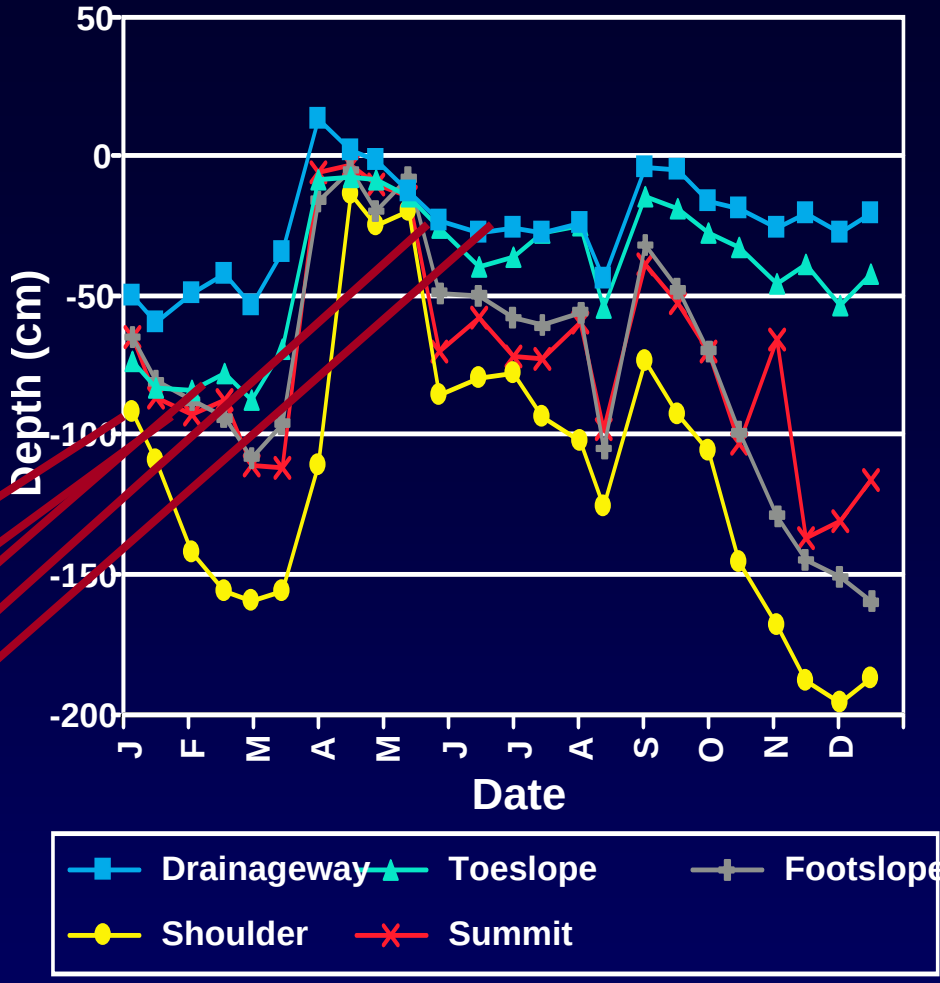


Waseca, Minnesota



Time + Space

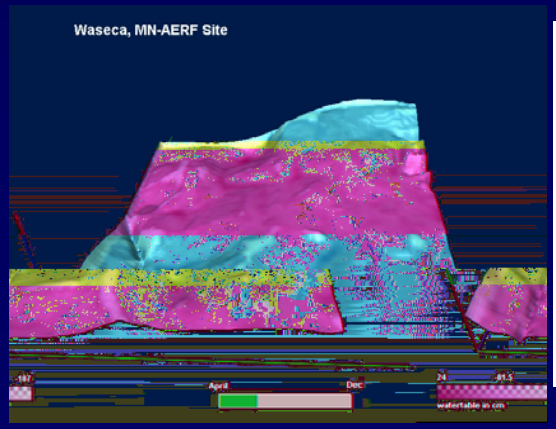


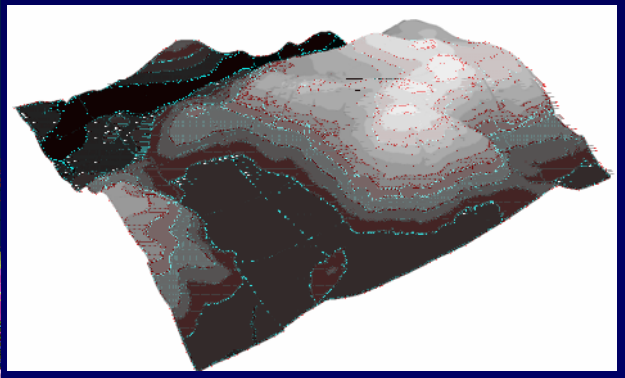

50
0
-50
-100
-150
-200
Depth (cm)
J
F
M
A
M
J
J
A
S
O
N
D
Date
Drainageway
Toeslope
Footslope
Shoulder
Summit

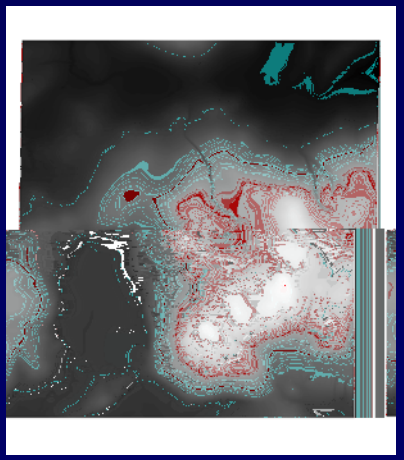
Scientific Visualization Animations

Applications

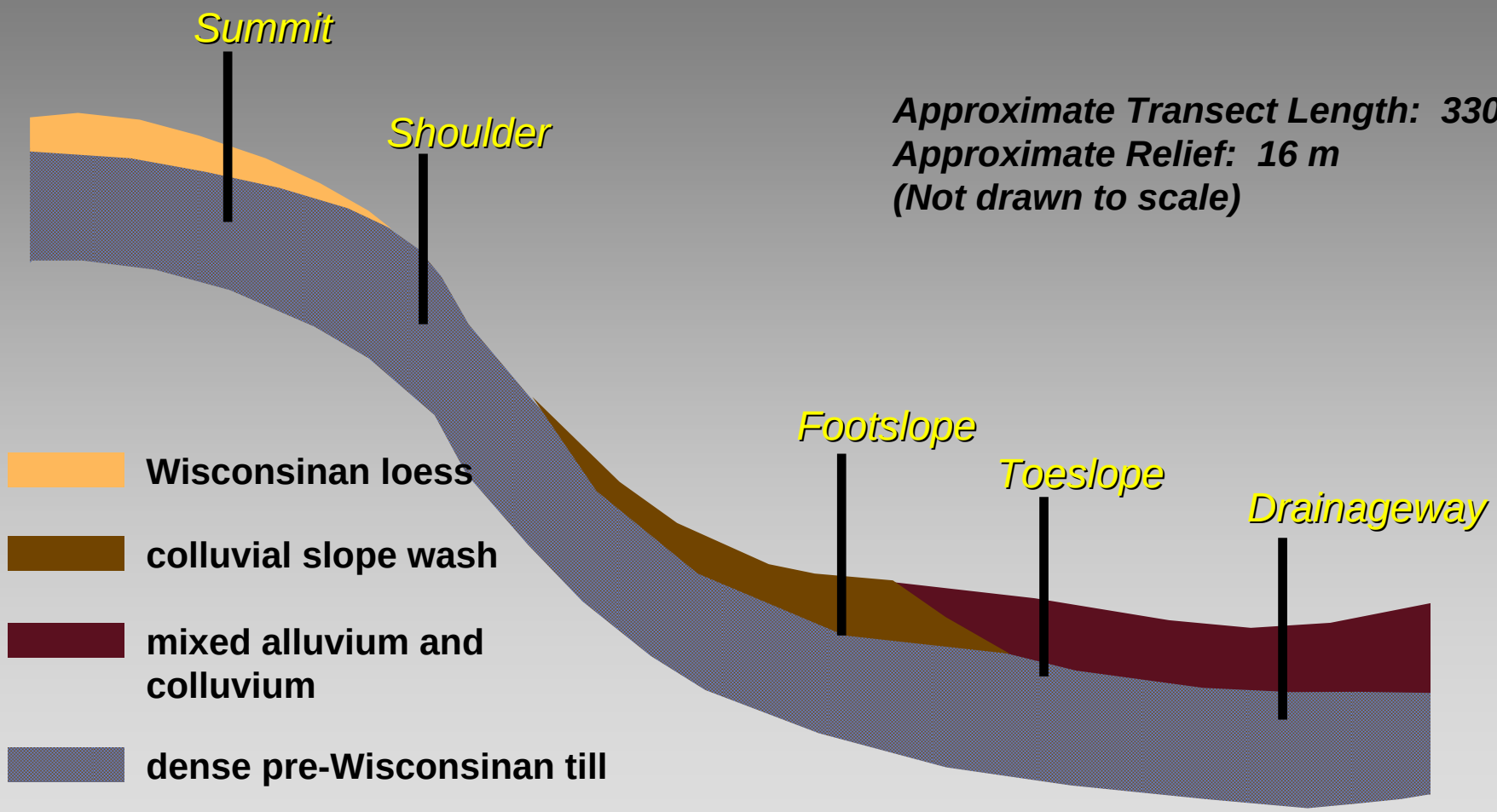
- Teaching
- Research
- Soil Resource Management







Hillslope Transect



Approximate Transect Length: 330 m
Approximate Relief: 16 m
(Not drawn to scale)

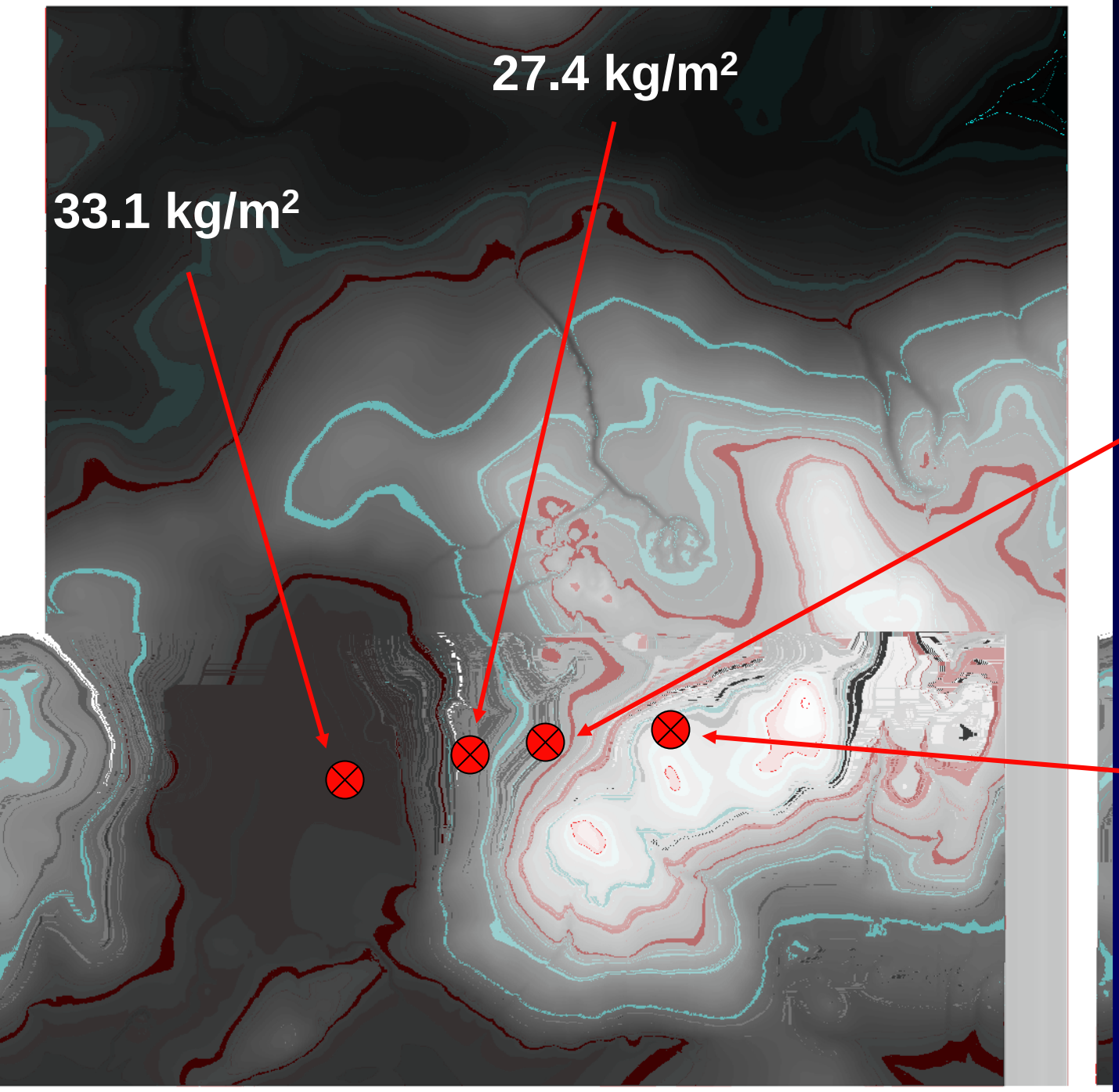
Toposequence

Summit

Shoulder

Footslope

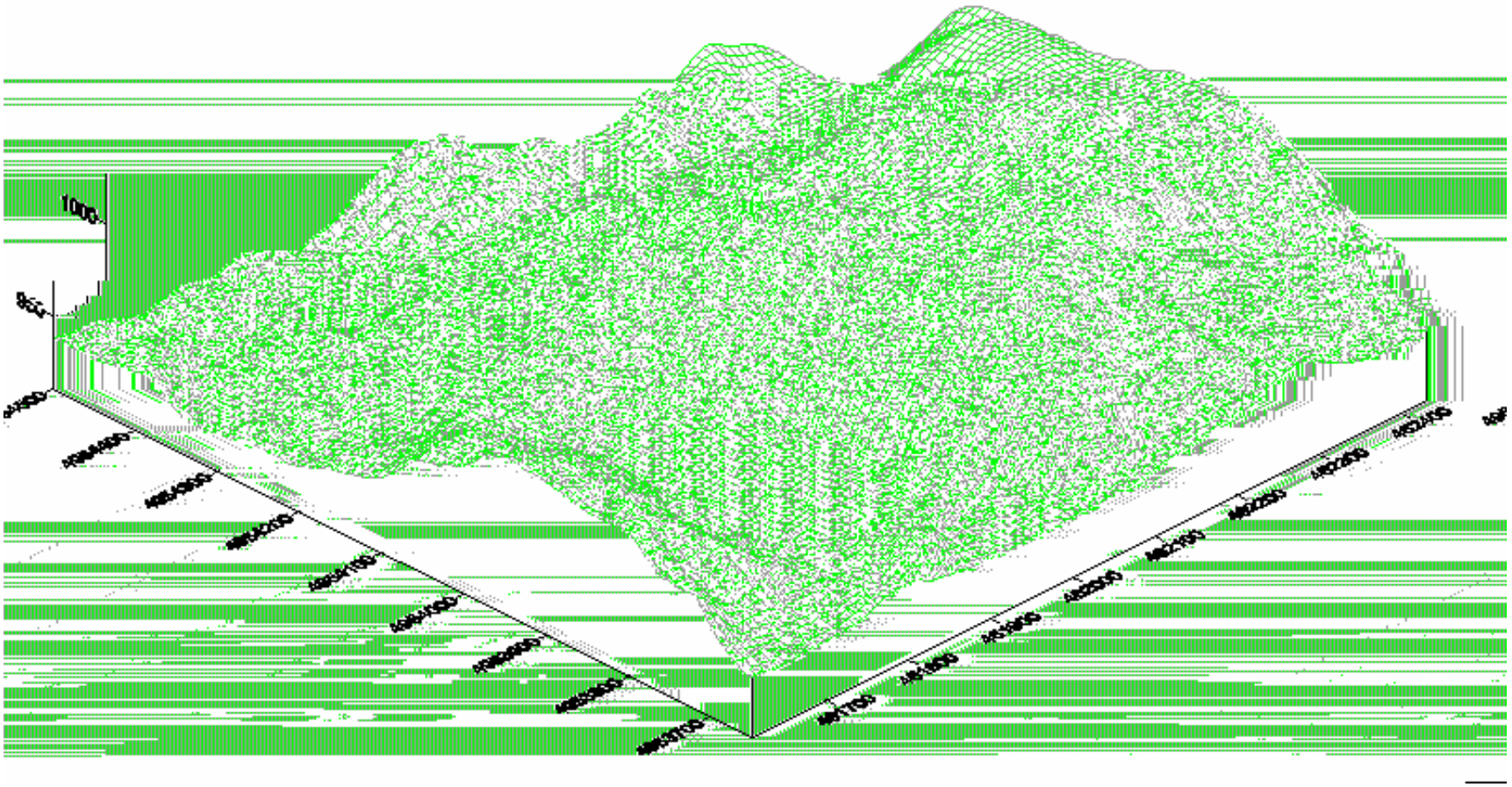
Toeslope



Soil Organic Carbon

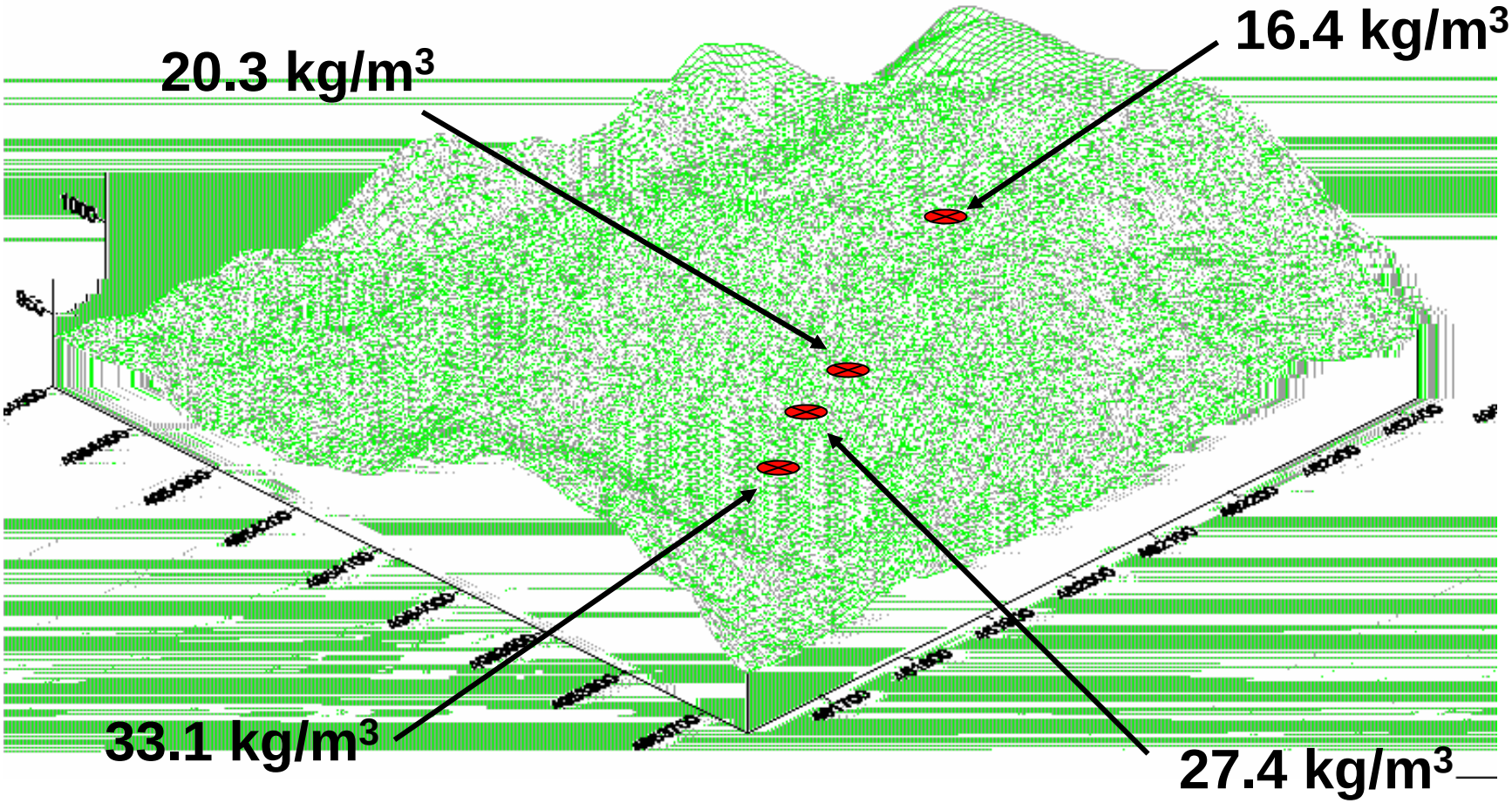
65 hectares

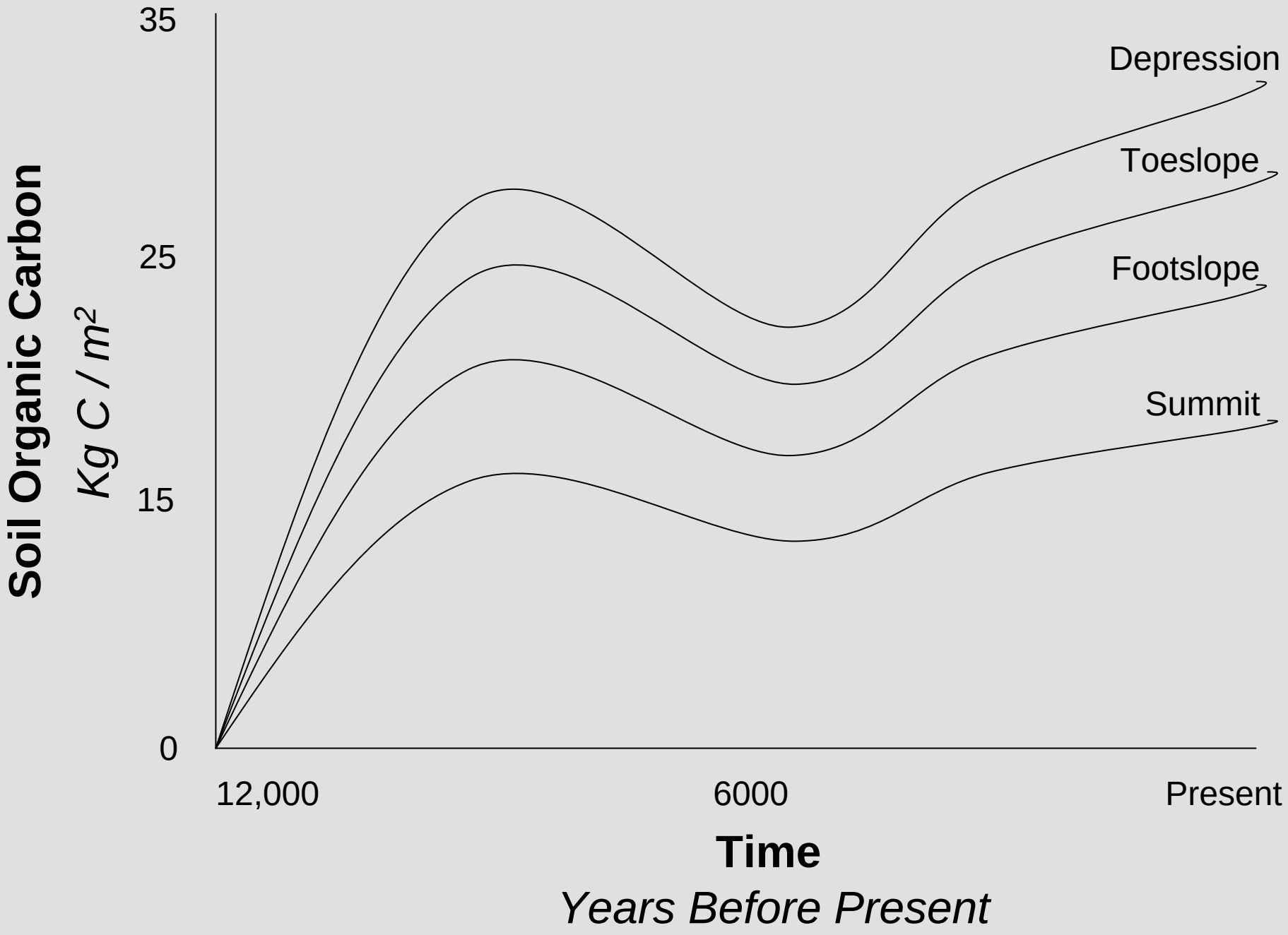
Topography

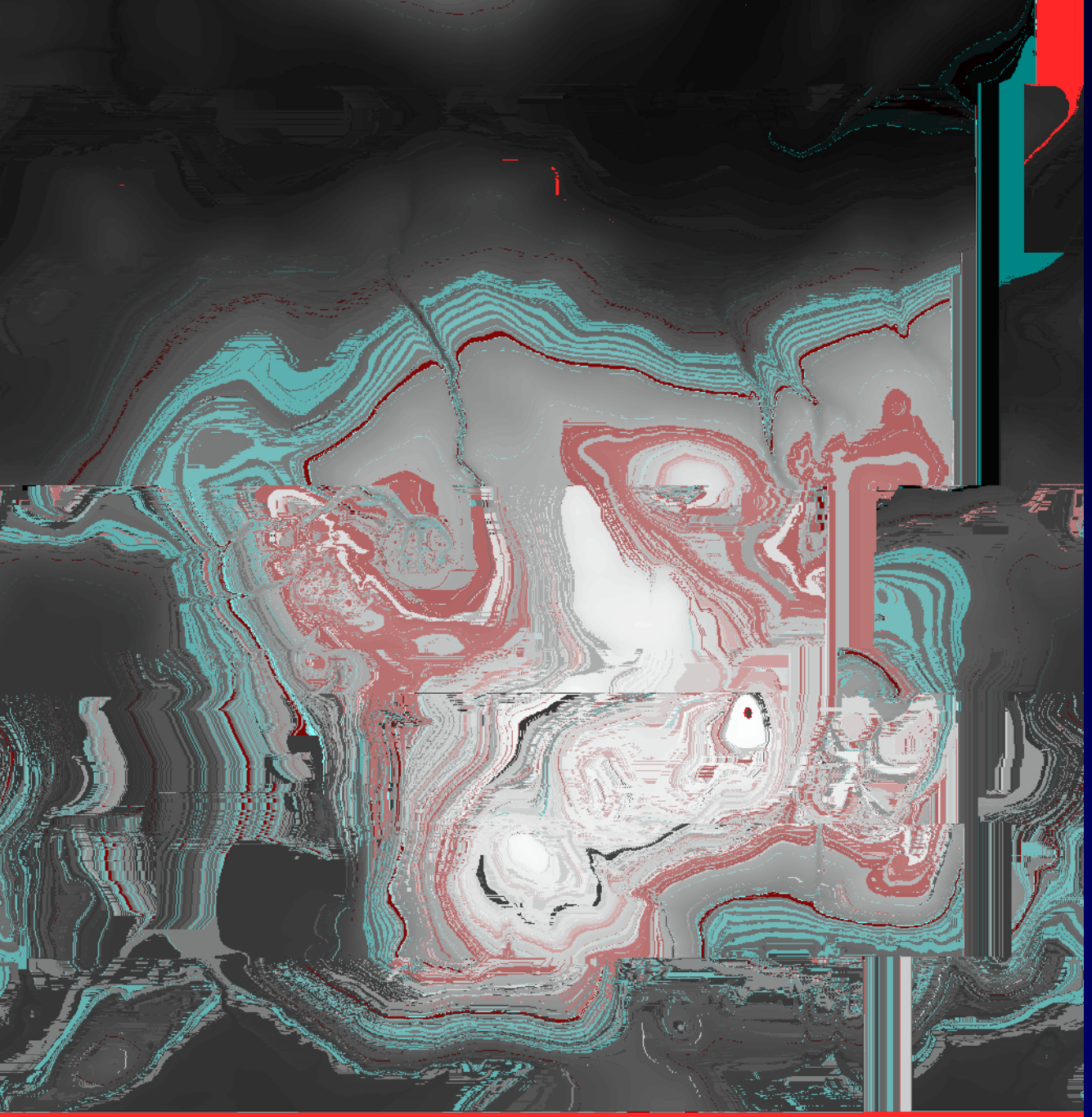


Soil Organic Carbon

Present




Soil Organic Carbon
Kg C / m²
35
25
15
0
Depression
Toeslope
Footslope
Summit
12,000
6000
Present
Time
Years Before Present



Spatial-Temporal Animation Soil Organic Carbon

Low High

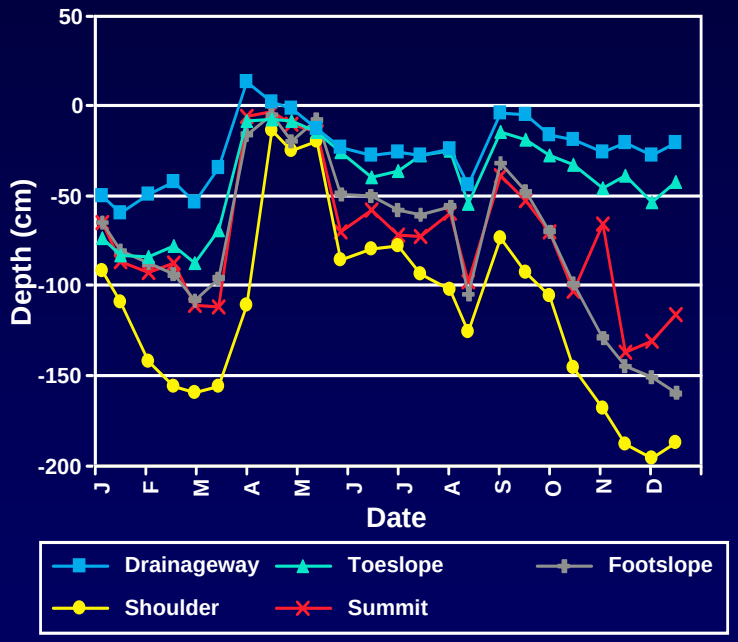
12,000 ybp

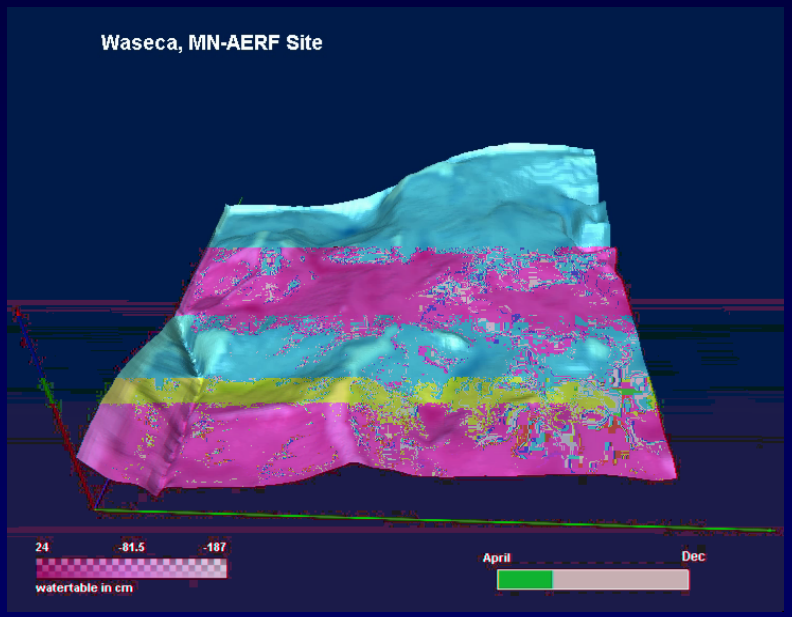
6000 ybp

Present

65 hectares

Annual Time Scale



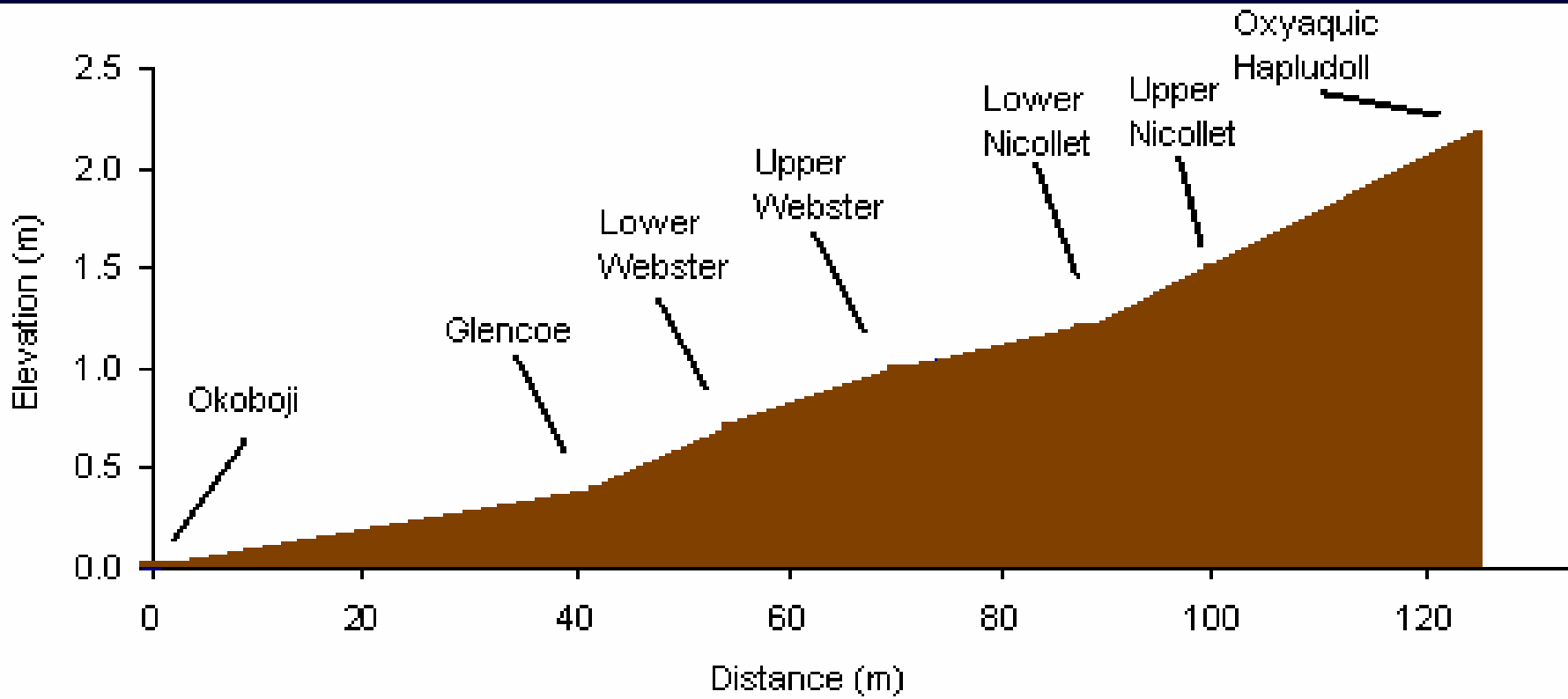


Soil Hydrology

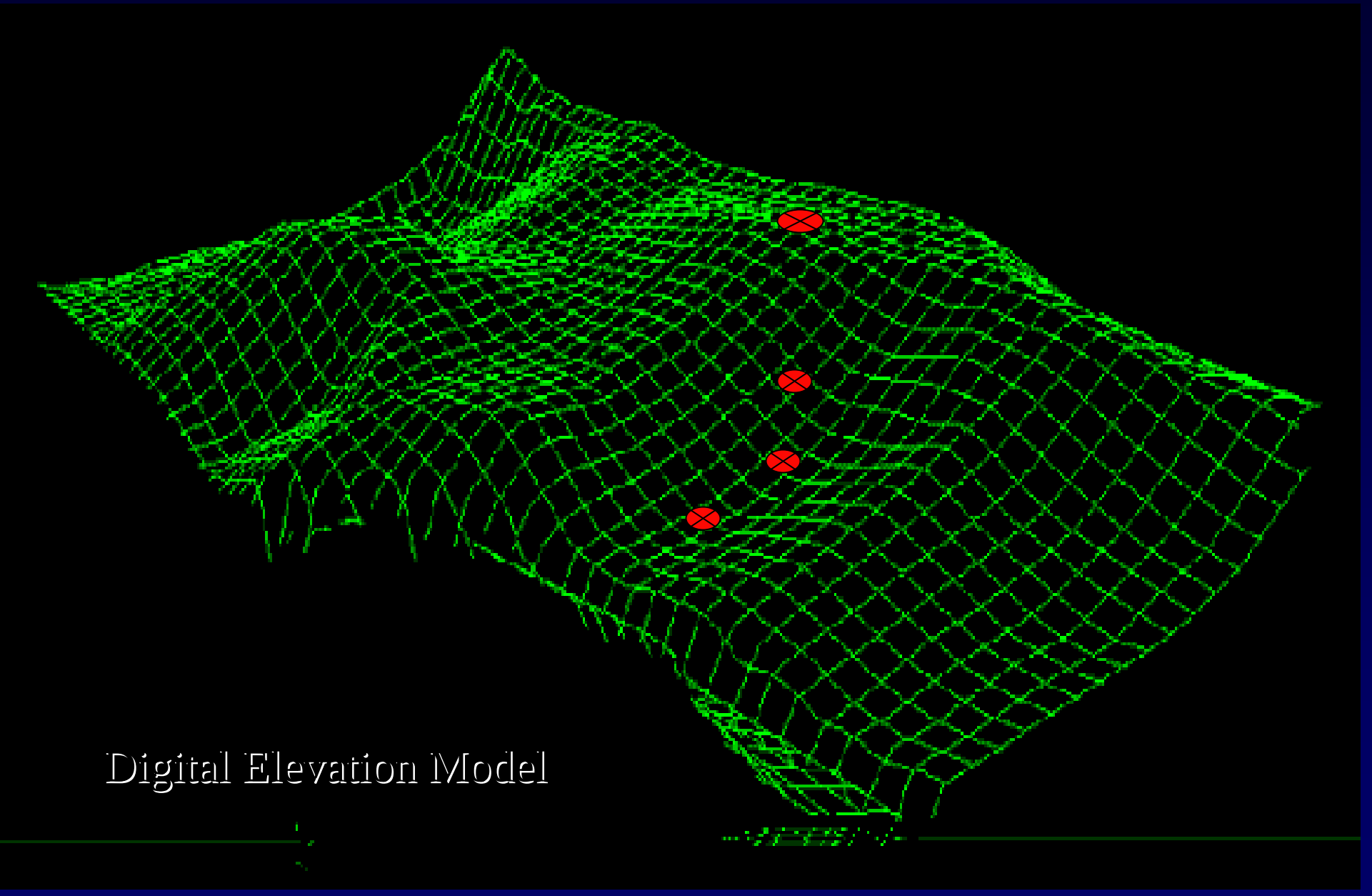

N
Minneapolis/ St. Paul
Minnesota
Waseca
Ground Moraine
Stagnation Moraine
Alluvium
Glacial Lake Sediments
Peat
5 0 5 10 15 20 Miles

Southern Minnesota Topography

Monitoring Transect – Waseca, MN



Waseca, Minnesota



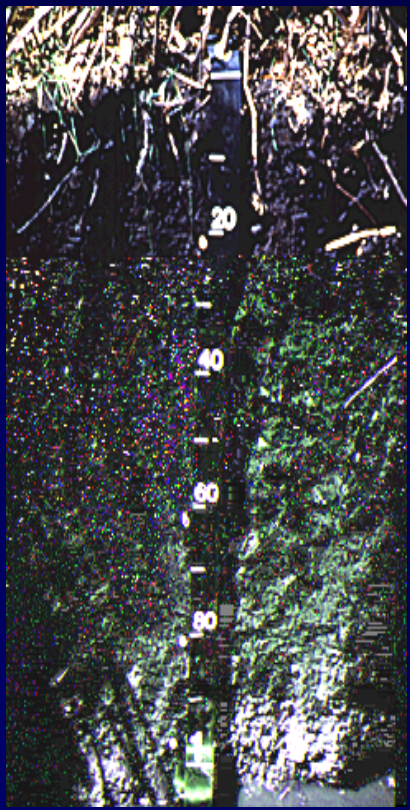
Waseca, Minnesota
Soil Toposequence

Summit

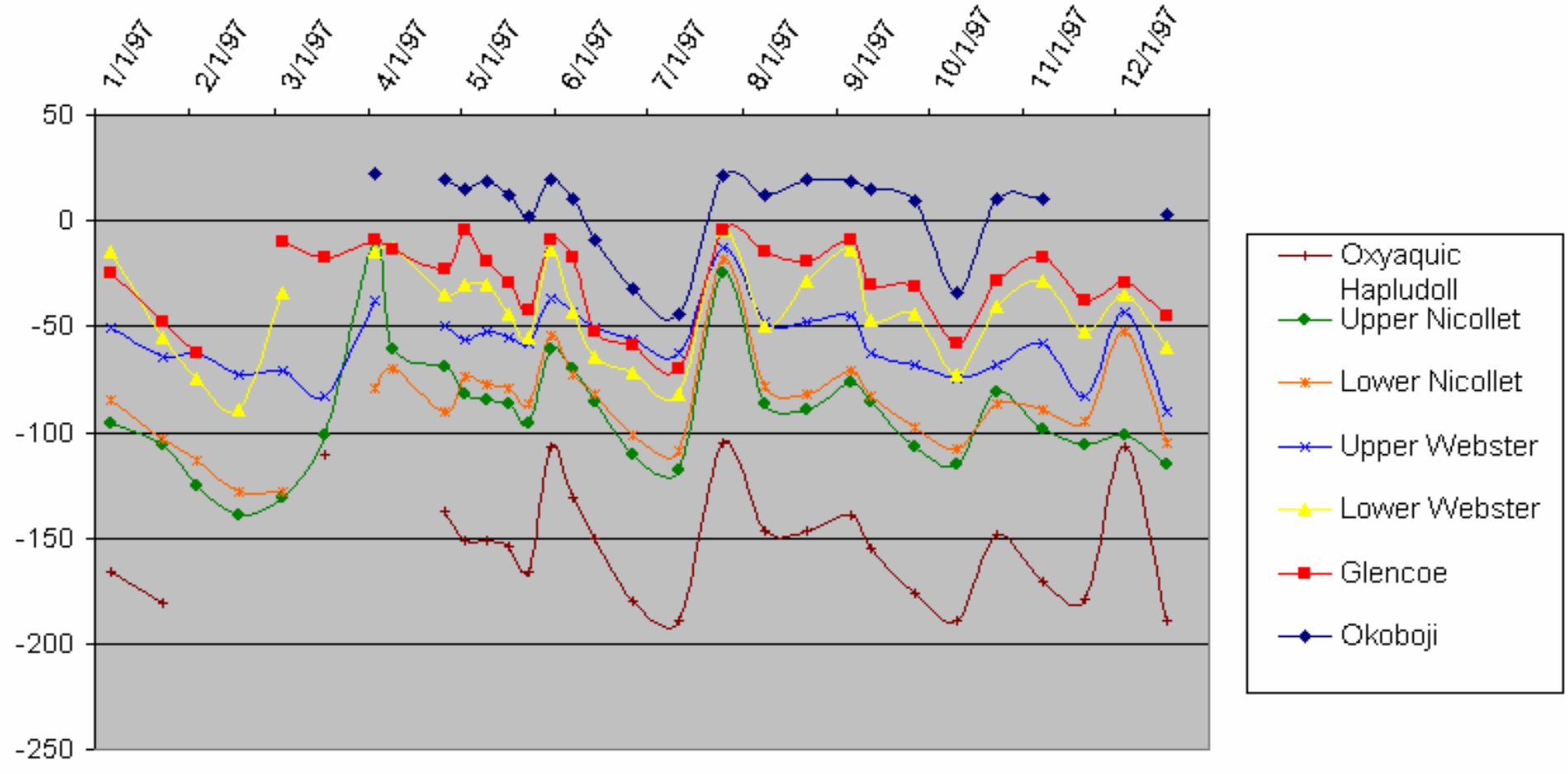
Lower Sideslope

Footslope

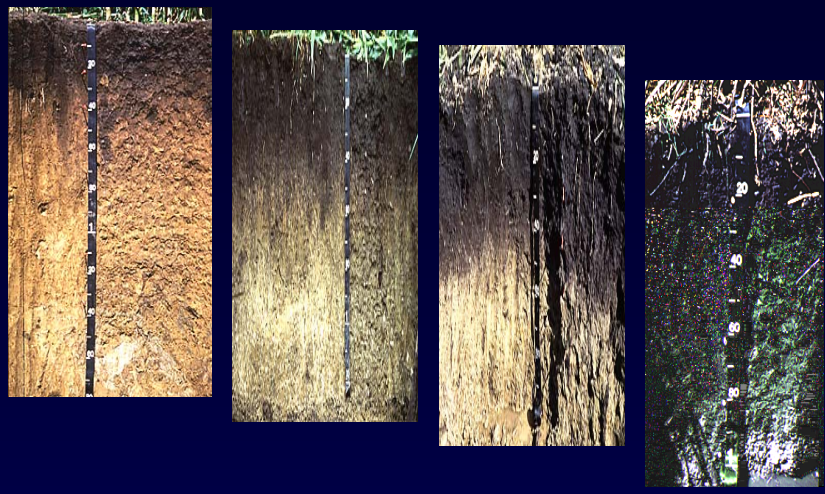
Toeslope



1997

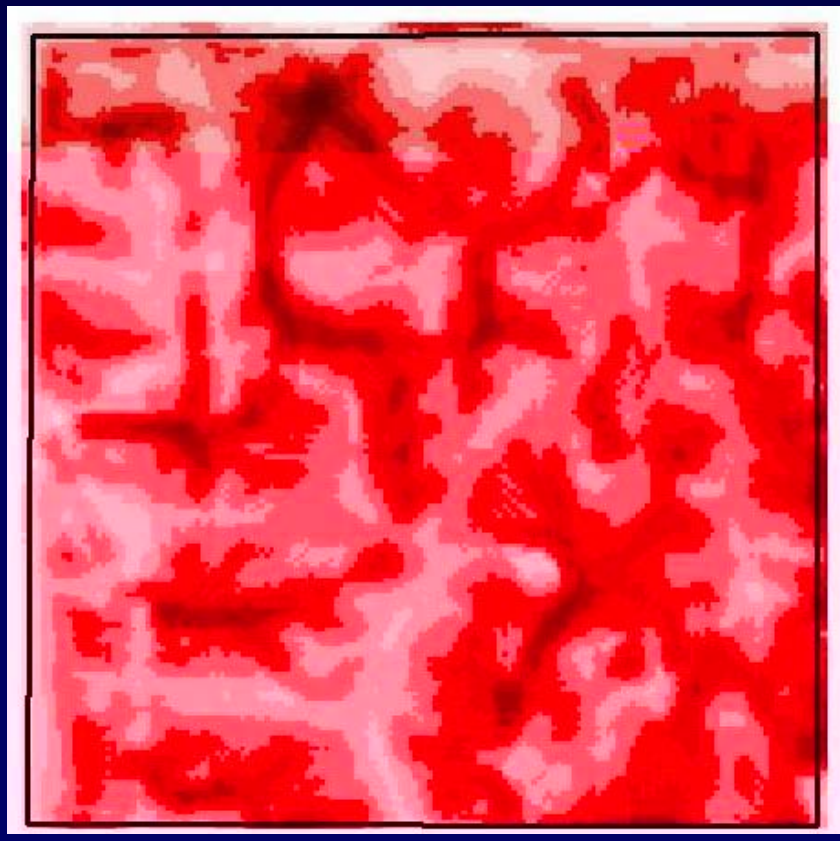

1/1/97
2/1/97
3/1/97
4/1/97
5/1/97
6/1/97
7/1/97
8/1/97
9/1/97
10/1/97
11/1/97
12/1/97
50
0
-50
-100
-150
-200
-250
Oxyaquic Hapludoll
Upper Nicollet
Lower Nicollet
Upper Webster
Lower Webster
Glencoe
Okoboji

Extrapolating to the 3-D Landscape



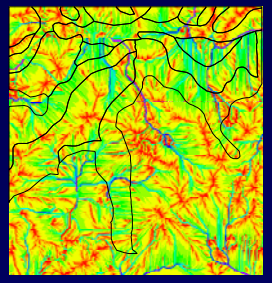
Soil-Landscape Modeling

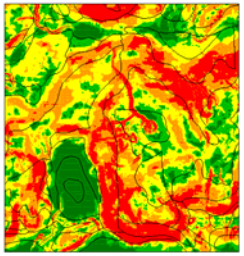
Soil Drainage Class Prediction

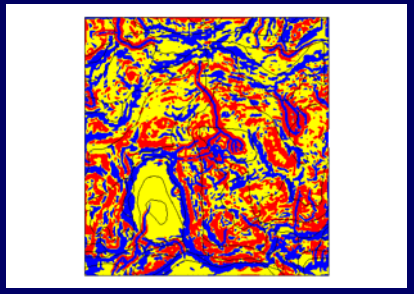


Model Development

Field
Observations







Field Sampling

- Grid soil sampling: 302 points

Drainage Class Prediction

$$C_j = c_{j0} + C_{j1}X_1 + C_{j2}X_2 + \ldots + C_{jp}X_p$$

C_j=Probability of Class j

X= terrain attribute

C= classification coefficient (matrix)

j= drainage class

c_{j0} = constant

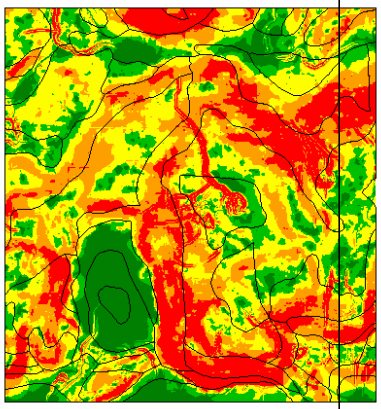
Model Calibration

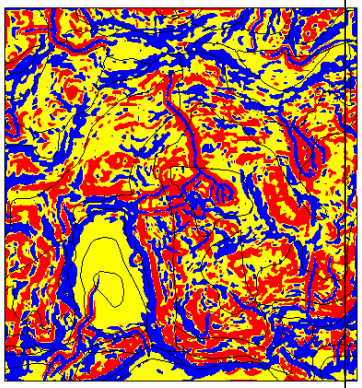
- Drainage class separation
  - Weakest: poorly and very poorly
  - Strongest: moderately well/somewhat poorly and very poorly

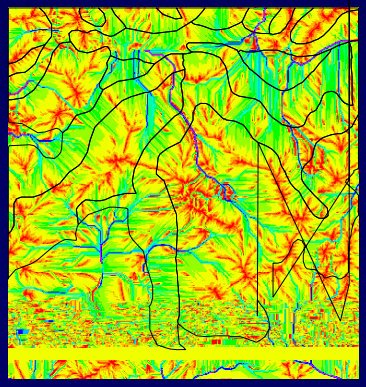
Model Validation
(Bootstrap Validation Approach)

- Soil-Landscape Model
  - 15-m DEM: best predictive capability
  - Classification Accuracy: 74%
  - 3% misclassified >1 drainage class away

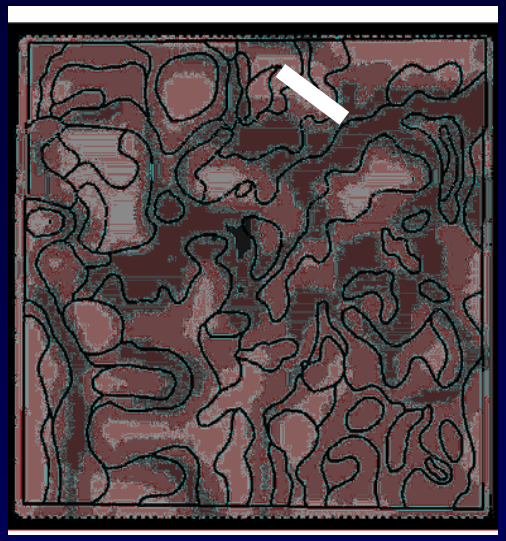
Model Application



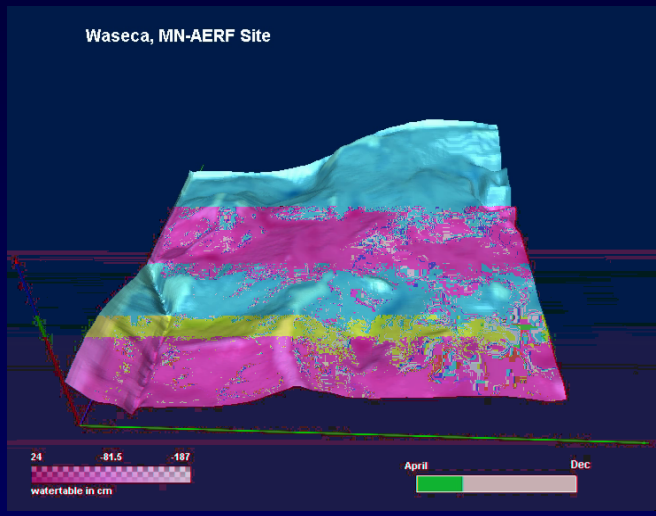


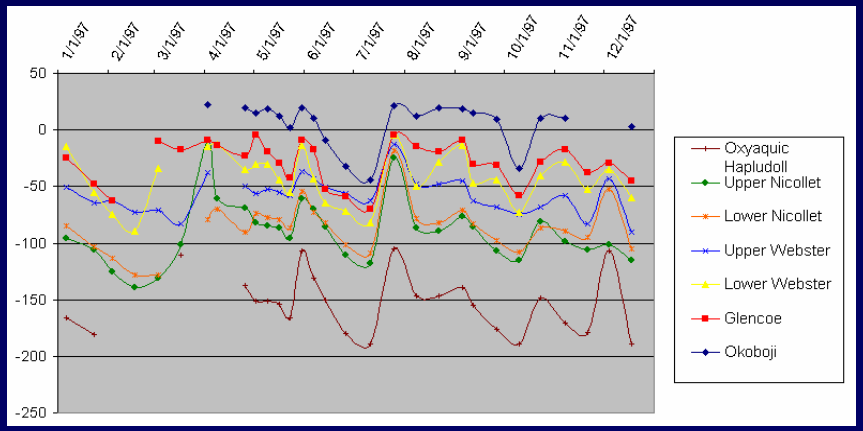


Probability of Poorly Drained Soil For Each Monitoring Site



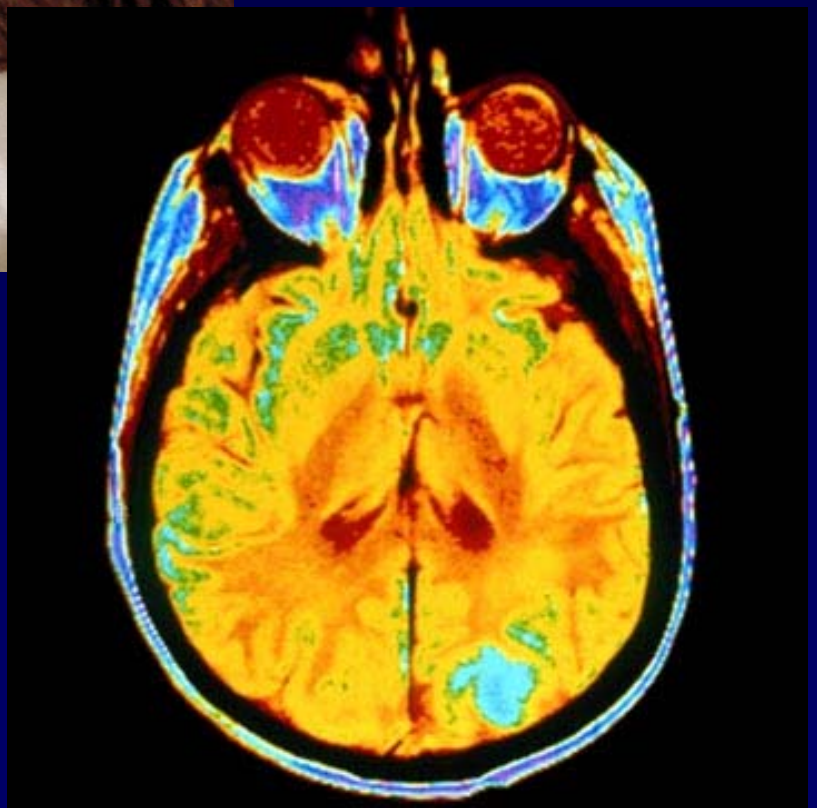
Interpolate





Magnetic Resonance Imaging (MRI) Analysis Software

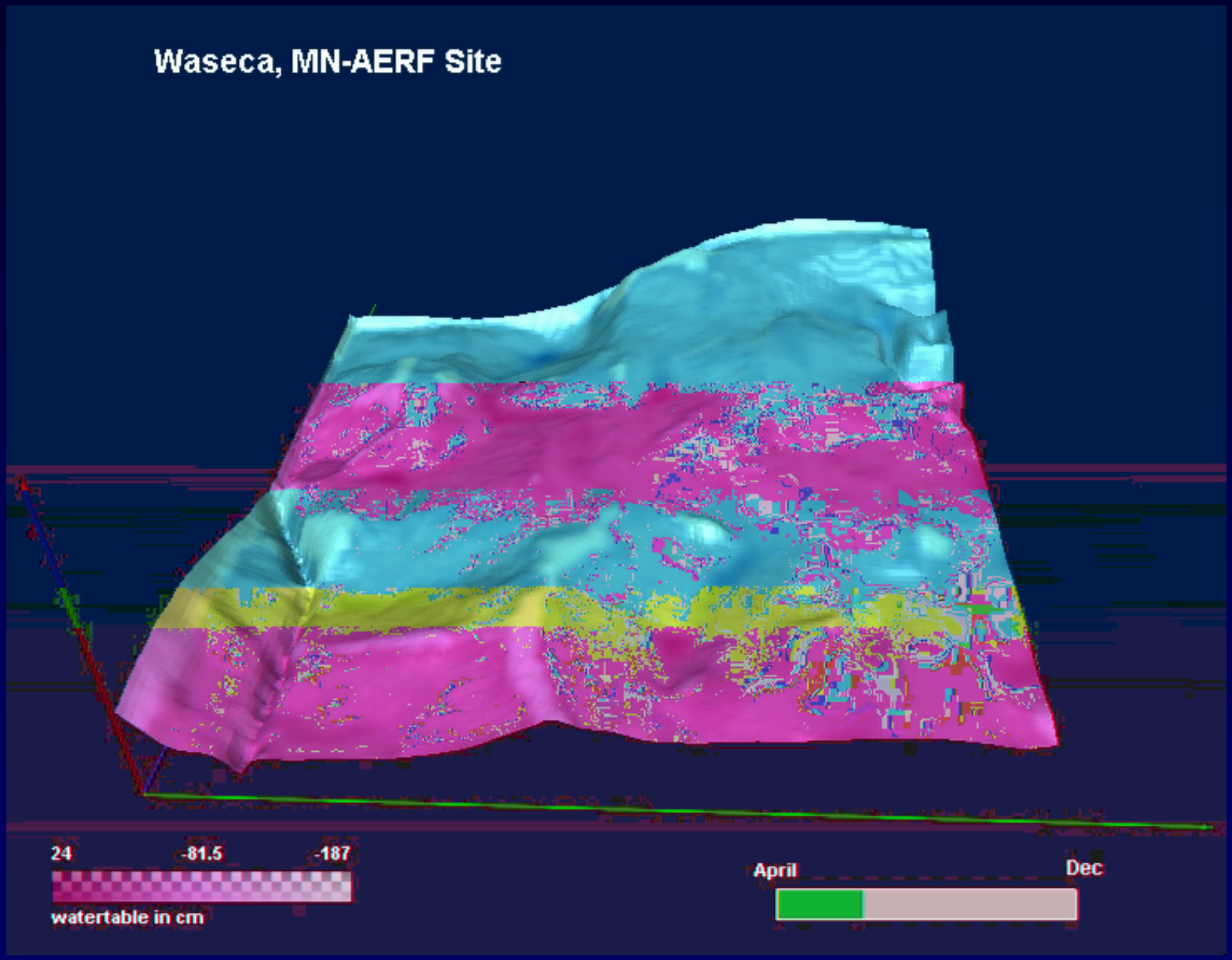
Amira

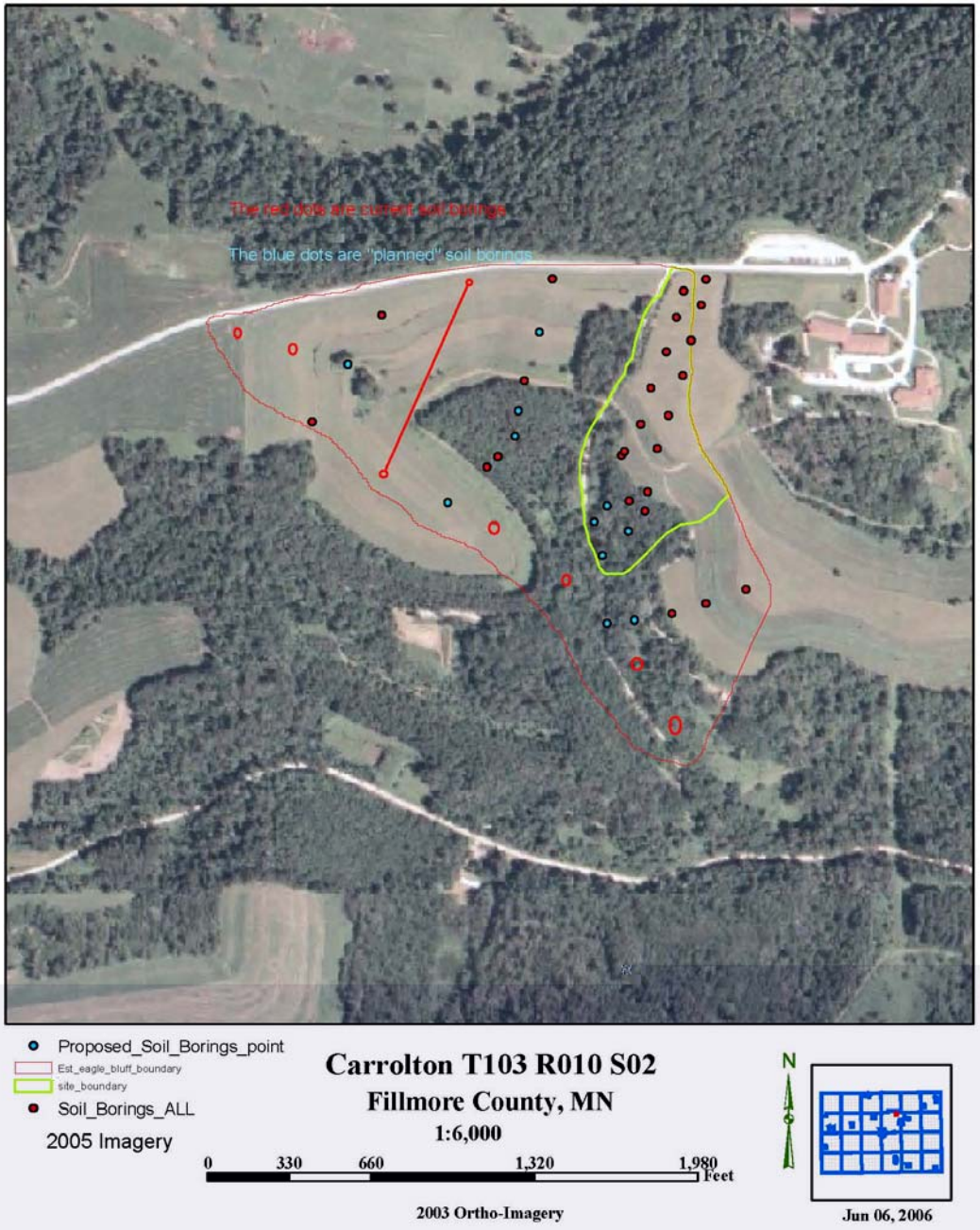


Brain Scan

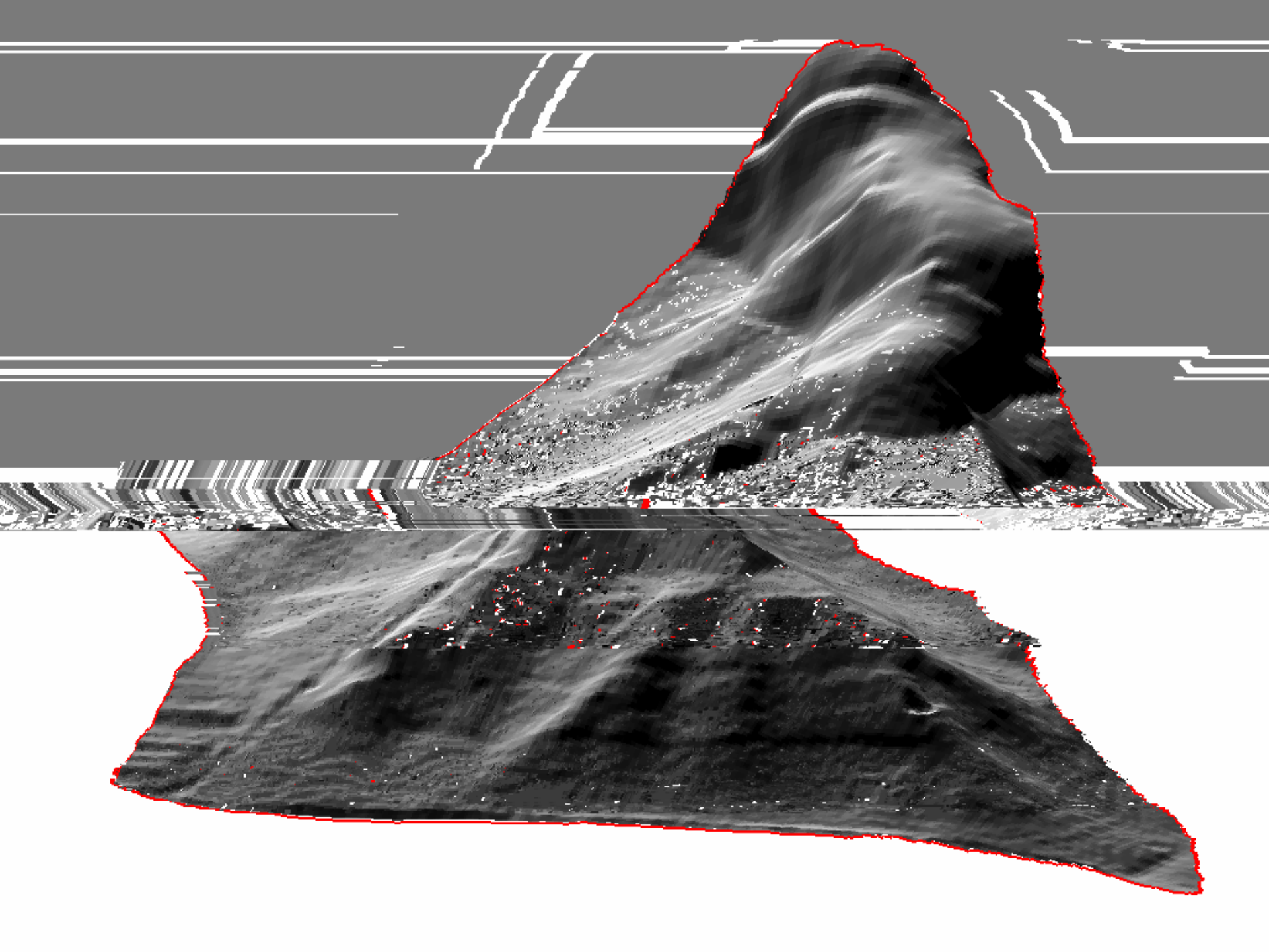
Supercomputing Institute

University of Minnesota


Waseca, MN-AERF Site
24
-81.5
-187
watertable in cm
April
Dec



- John Beck
- Joel Nelson
- UM Supercomputer Institute
- NRCS National Geospatial Development Center
- National Soil Survey Lab



Minor
Lateral
Flow

A

Bt

BC

C - loess

Major
Lateral
Flow

Depleted Loess

Old Red Till